# Measuring disability in patients with chronic low back pain

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# Matching FCE activities and work demands
An explorative study

## Chapter 8

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# Abstract

**Objectives.** To explore to what extent the standardized Isernhagen Work Systems Functional Capacity Evaluation (IWS FCE) can be matched with observed work demands in workers with chronic low back pain, and, secondly, to explore whether this match can predict sick leave in the year after rehabilitation treatment.
**Methods.** An explorative prognostic cohort study with a one-year follow-up (four, eight and twelve months after baseline) was performed (n=18). Demographics, back complaints and FCE performance were assessed at baseline. In addition, a workplace assessment (WPA) was performed. Eleven FCE activities were matched with work demands. Sick leave associated with low back pain and physical and psychosocial work demands were assessed during follow-up.
**Results.** Seven activities could be directly matched with WPA data. (Carrying, pushing, pulling, crouching, kneeling, static forward bending, and dynamic bending and rotating.) For some workers, difficulties existed in matching three of the activities (pushing, pulling and crouching). One activity (lifting) could indirectly be matched with WPA data. One activity (walking) could not be matched with WPA data. Two activities (sitting, standing) were excluded from analyses due to practical limitations. No relation was found between FCE performance, work demands, and sick leave during follow-up.
**Conclusions.** Seven FCE activities could be directly matched with work demands. However, not all observed work demands could be matched with IWS FCE activities in the eighteen occupations studied. This quantitative and standardized way of assessing work-related disability is not sufficient to predict work ability and sick leave at the present time.

# Introduction

Low back pain is a major problem in Western society. Most people (70-85%) suffer from low back pain (LBP) once in their life, but most back pain resolves itself within four to six weeks after onset.[1,2] The pain becomes chronic in some cases (about 10%) and may lead to disability in daily living and work. Previous studies showed that disability seems to be one of the major determinants when seeking healthcare.[3-5] One of the aims of treatment in rehabilitation medicine is to improve functioning in work or work-related activities for patients with chronic low back pain (CLBP). In so doing, it is assumed that work capacity (total of all physical, cognitive and emotional characteristics of the worker)[6] and work demands can be balanced, and that sick leave associated with CLBP can be reduced. This assumption is based on the model of work load and work capacity[6,7] as recently expanded within the definitions of the International Classification of Functioning, Disability and Health (ICF).[8] Although it is assumed that work capacity and work demands are balanced after rehabilitation treatment for CLBP, many patients have recurrences of complaints, repeated sick leave, and seek medical care once again.[3] It is not clear whether this is caused by an imbalance between work capacity and work demands. To evaluate the treatment outcome and to predict disability and functioning after treatment, work capacity in relation to work demands should be assessed.

Assessment of work capacity is not an easy task because it involves human action. This means that in most assessment methods, performance and not capacity is what is being measured, and performance is based on a person's capacity and the willingness to make this capacity or part of this capacity available.[9] Functional Capacity Evaluations (FCEs) are frequently used in rehabilitation medicine in order to assess the performance of work-related activities.[10] Different FCEs are available and one of the better known is the Isernhagen Work Systems FCE (IWS FCE). The IWS FCE consists of twenty-eight work-related tasks based on the Dictionary of Occupational Titles (DOT).[10-12] Several subtests of the IWS FCE have proven to have good reliability in patients with CLBP.[13] In order to evaluate the treatment outcome and to predict sick leave after treatment, it is also important to know whether the FCE is capable of measuring the ability to perform work-related activities, and this over time (during an eight-hour working day, five days a week, year after year), as well as whether it can contribute to the prediction to a successful return to work (construct and predictive validity). Whether the FCE is able to predict the ability to perform work-related activities over time is still unknown. It is known, however, that performance of IWS FCE activities are poor to moderately related to a return to work.[14-19] It is not clear, though, whether this lack of predictive validity is caused by a mismatch between performance of FCE activities and work demands or by something else.

Several studies have attempted to match performance of IWS FCE activities to work demands. A previous study matched FCE activities mainly with self-reported work demands.[17] In another study FCE activities and work demands were matched by classifying each job according to the lifting levels of the DOT.[20] Self-report has a low validity with respect to exposure level and variation in assessing work demands.[21] Therefore, in the match between FCE activities and work demands, it is preferable to use observation when determining information about amplitude, frequency and duration of work demands.[22] Previous study attempts did not result in a direct comparison of performance of FCE activities and observed work demands.

The aim of this study is to explore to what extent the standardized IWS FCE can be matched to observed work demands in workers with CLBP. Secondly, we want to explore to what extent this match can predict sick leave in the year after rehabilitation treatment.

# Methods

### Design

An explorative prognostic cohort study with a one-year follow-up (four, eight and twelve months after baseline) was performed to investigate the match between performance of FCE activities and work demands and their relation to sick leave in the year after rehabilitation treatment (n=18). At baseline (after finishing rehabilitation treatment) workers performed an FCE; and demographics, back complaints and sick leave in the previous year were assessed. In addition, a workplace assessment (WPA) was performed assessing work demands. Follow-up measurements were performed four, eight and twelve months after baseline by means of questionnaires which assessed back complaints, sick leave associated with CLBP, and (change in) physical and psychosocial work demands. The study was approved by the medical ethics committee of the University Medical Centre Groningen, the Netherlands.

### Study sample

Workers were enrolled after they finished the multidisciplinary rehabilitation treatment for CLBP. CLBP was defined as non-specific recurrent low back problems over a period of years, or as having a new episode of non-specific LBP of at least three months' duration. Inclusion criteria were between 18 and 65 years of age, either currently at work or not working for less than one year due to CLBP. Exclusion criteria were CLBP with an underlying specific cause, cardiovascular or pulmonary diseases, hypertension, pregnancy, drug addiction and psycho-pathology. Eleven men and seven women participated in this study. All signed informed consent agreements. The mean age of the workers was 41.2 years (SD 8.4). Twelve workers had been on sick leave in the previous twelve months, with a mean duration of 20.5 weeks (SD 11.7; range 8-40). All workers were working at the time of enrolment.

**Functional Capacity Evaluation**

The IWS FCE[23] was used to assess the performance of work-related activities. The activities of lifting, carrying, pushing and static pulling, crouching, kneeling, forward bending static standing, dynamic bending and rotating, sitting, standing, and walking were compared with work demands. These activities all had an acceptable reliability.[13]

**Workplace assessment**

Workers were sent a questionnaire querying physical work demands and sequences of work tasks. The four most strenuous working tasks according to the worker (as derived from the questionnaire) were observed through both direct registrations at the workplace and video registrations. The normal timing of the performance of the most strenuous tasks determined the day of observation and a "true-to-nature" observation was carried out. In general, ten-minute registrations were made of the left or right side of the worker. However, if a working task had a cycle duration of more than ten minutes, then at least one full cycle was observed. A video camera, stopwatch, push and pull dynamometer, balance, goniometer, heart-rate monitor with memory (Polar S610), and measuring tape were used. During the WPA, additional data on weights, (travel) distances for manual materials handling (MMH), heights of tables, chairs and cupboards, and anthropometrics were assessed. This measurement protocol was based on the literature,[24,25] but the reliability and validity of the WPA was unknown. Heart rate registrations performed with a heart-rate monitor were entered into the computer and analysed afterwards. Video registrations were analysed with Noldus Observer [a], which is a tool for collecting and analysing observed data. The Observer does not actually collect data automatically; instead the user must register when a specific type of behaviour occurs. To be able to match performance of FCE activities and work demands, a classification scheme attuned to the FCE activities was developed to score work-related activities. The scheme was pilot tested by five observers and the scheme and operational definitions of activities were adjusted until agreement between different observers was reached. The observed activities were similar to those assessed by the FCE. Operational definitions of activities are presented in the appendix. In each activity, frequency, maximum duration and total duration were registered.

**Sick leave**

Sick leave associated with LBP was assessed during follow-up. The total number of sick-listed weeks was assessed (including working on modified duties, working

[a] The Observer, Noldus Information Technology B.V. Nieuwe kanaal 5, P.O. Box 268, 6700 AG Wageningen, The Netherlands. Web: www.noldus.com.

fewer hours, and completely off work) and the frequency of sick listing was assessed.

**Work-related characteristics**
Job name, magnitude and kind of occupation were registered for each worker. Jobs were classified in terms of blue- and white-collar. In addition, the subject's own expectation of returning to work during the one-year follow-up was assessed with a five-point scale (no return to work [RTW], partly RTW new job, full RTW new job, partly RTW previous job, full RTW previous job). In the four, eight and twelve-month follow-up, physical exertion and need for recovery were measured with subscales of the Dutch version of the questionnaire on Perception and Judgment of Work (VBBA).[26] The scales were standardized and ranged from 0 (low) to 100 (high). The scales are considered as having good reliability and validity.[26-28] Fear avoidance beliefs about work were assessed with the Dutch version of the work scale of the Fear Avoidance Beliefs Questionnaire (FABQ-work).[29,30] The scale ranges from 0 (low fear) to 42 (high fear). The FABQ-work has good reliability and validity.[29-33]

**Analyses**
An exploration was conducted as to what extent FCE activities could be matched with the observed data of the WPA. If a direct match was not possible or justified, an indirect match was searched. Possible matches were described for each activity separately. Workers were classified in terms of equal or higher abilities than demands (FCE ≥ WPA), lower abilities than demands (FCE < WPA), or unknown relationship between abilities and demands (FCE ? WPA). The reason for the unknown relationship between abilities and demands was described. Dynamic bending and rotating were analysed as one activity because it was not possible to register these observed work demands separately. Sick leave was dichotomised as having sick leave during the past year or not. The relation between sick leave and the variables of work abilities and work demands, age, gender, white or blue-collar worker, magnitude and kind of occupation, the subject's own expectations, VBBA physical exertion and physiological overload scales, and FABQ-work, were described.

# Results

**Matching FCE activities and work demands**
In table 8.1, the comparison between FCE activities and work demands and their relation to sick leave are presented per activity for all eighteen workers.

**Table 8.1.** Matching FCE activities and WPA data and their relation to sick leave: a comparison per activity for eighteen workers

| Matching FCE and WPA | FCE < WPA | | FCE ≥ WPA | | FCE ? WPA | |
|---|---|---|---|---|---|---|
| Sick leave | Yes | No | Yes | No | Yes | No |
| *Activity* | *n* | *n* | *n* | *n* | *n* | *n* |
| Lifting | - | - | 4 | 8 | 2 | 4 |
| Carrying | - | - | 6 | 11 | - | 1 |
| Pushing | - | 2 | 4 | 9 | 2 | 1 |
| Pulling | - | 1 | 4 | 9 | 2 | 2 |
| Crouching | - | - | 4 | 12 | 2 | - |
| Kneeling | - | - | 5 | 12 | 1 | - |
| Static forward bending | - | - | 6 | 12 | - | - |
| Dynamic bending and rotating | - | - | 5 | 12 | 1 | - |

Note. FCE = Functional Capacity Evaluation, WPA = Workplace Assessment; FCE < WPA = performance on FCE lower than performance at work; FCE ≥ WPA = performance on FCE equal to or higher than performance at work; FCE ? WPA = relation between FCE performance and performance at work unknown; Six persons had sick leave during the one-year follow-up

Lifting

Lifting could not be directly matched with the observed data of the WPA due to differences in duration, frequency and the demands of the working task. Therefore, the lifting guideline of the National Institute of Occupational Safety and Health (NIOSH)[34] was used as intermediate to correct for different situations. NIOSH developed an equation to calculate a recommended weight limit (RWL) in a specific occupational setting. RWL was calculated for the specific FCE situation and the worker was classified in terms of being able to perform above the RWL of the NIOSH or not. In addition, RWL was calculated for the specific lifting tasks required at work and compared with the actual weights that were lifted during that work task. In the match between FCE and WPA, three situations were possible: 1. Performance on the FCE activity was higher than the RWL calculated for the FCE activity *and* performance during the work-activity was lower than the RWL calculated for the work-activity (FCE ≥ WPA). 2. Performance on the FCE activity was lower than the RWL calculated for the FCE activity *and* performance during the work-activity was higher than the RWL calculated for the work-activity (FCE < WPA). 3. Performance on the FCE activity was lower than the RWL calculated for the FCE activity *and* performance during the work-activity was lower than the RWL calculated for the work-activity, or performance on the FCE activity was higher than the RWL calculated for the FCE activity *and* performance during the work-activity was higher than the RWL calculated for the work-activity (FCE ? WPA). It was observed that in twelve workers performance on FCE activities exceeded the work demands. Performance of FCE activities was never lower than the work demands. The relation between FCE and WPA was unknown for six workers. One worker performed below RWL on the FCE, but at work the (lifting) work demands were also below RWL. The remaining five workers performed above RWL at the FCE lifting task, but at work, the observed lifting weight was also higher than the calculated RWL of the work task.

Carrying

Carrying was measured in both the FCE and WPA as short carrying, two-handed long carrying, left-handed long carrying and right-handed long carrying. As a result, WPA data could be directly matched with the different activities from the FCE. Seventeen workers performed on the FCE above the observed work demands. In one worker the relation between FCE and WPA was unknown because of missing data in the FCE.

Pushing and pulling

The activities "pushing" and "pulling" could be directly matched with the observed data from the WPA. Because only the FCE activities of pushing and static pulling were used, only data observed on peak forces during pushing and pulling were matched with FCE data and not continuous forces over an extended period of time. With regards to pushing, it was not possible to match FCE activities and work demands for three workers because it was observed during the WPA that these workers pushed with one hand during the task. With regards to pulling, it was not possible to match FCE activities and work demands for four workers either because it was observed during the WPA that these workers pulled with one hand during the activity (n=2) or because the pull-forces were not measured at the workplace because the dynamometer could not be attached to the object pulled (n=2).

Crouching, kneeling, forward bending static standing, and dynamic bending and rotating

All of these tests had ceiling or criterion effects on the FCE. A ceiling effect indicates that the test was terminated because the worker met what is defined to be the maximum performance time. When this is the case, workers have not performed to their maximum ability. The ceiling for crouching was sixty seconds; for kneeling, five minutes; and for forward bending static standing, fifteen minutes. A direct match for these activities was possible if a worker did not reach the ceiling or if the maximum holding time of the activity observed at work was lower than the FCE ceiling. A criterion effect indicates that a test was fulfilled when a criterion was met. Dynamic bending and rotating is a test with such a criterion effect, measuring the time needed to perform twenty (for bending) or thirty (for rotating) repetitions. The lowest number of repetitions performed was used in making the comparison with work demands. Kneeling, static forward bending and dynamic bending and rotating could be directly matched with the observed data of the WPA. Matching the FCE crouching activity with WPA data was limited. One worker exceeded the ceiling of crouching during the WPA (observed maximum holding time of eighty seconds) and thus the relation between FCE and WPA was unknown. For almost all workers FCE performance on these activities exceeded their work demands. It was noticeable during the FCE that forward bending static standing had a ceiling of fifteen minutes, while it was observed that the maximum holding time observed at the workplace in the eighteen workers was only seventy-six seconds. In four instances no comparisons could be made for crouching, kneeling or dynamic bending and rotating respectively, due to missing FCE data.

<u>Sitting and standing</u>
In the FCE, “sitting” and “standing” are measured as being able to sit continuously for a maximum duration of thirty minutes. All but one worker reached this ceiling. Because the WPA was aimed at observing the four most strenuous working tasks, simulation of tasks was sometimes necessary and this resulted in the interruption of prolonged sitting and standing tasks. Therefore, during the WPA workers did not sit or stand continuously over a period of thirty minutes. Because of this, we decided not to include these items for further analysis.

<u>Walking</u>
We attempted to compare the “shuttle walk test” of the FCE with the heart-rate registrations at the workplace. Although a heart-rate norm could be derived from results of the shuttle walk test, it did not justify matching this heart rate with the mean heart rate during the WPA. This occurred because we were not able to control for differences in the muscle groups used vis-à-vis factors such as temperature and emotional factors, which are factors essential for any such comparison.[35] Because different jobs were studied which had different physical demands, these factors could very well be different per job.

**Sick leave**
During the follow-up year, six workers (33%) were on sick leave due to LBP. The duration of sick leave was respectively one, two (two workers), three, six and thirteen weeks. The patient who was on sick leave for three weeks continued working with his duties modified and therefore did not report sick. Four workers reported sick only once and one patient reported sick twice (two weeks on sick leave). The number of activities per worker in which “FCE < WPA,” “FCE ≥ WPA” or “FCE ? WPA” is presented in table 8.2 in relation to sick leave during the follow-up year. In table 8.3 sick leave in relation to work characteristics is presented. No major differences were observed between workers with or without sick leave during the follow-up. Only one trend was seen for fear avoidance beliefs about work, and this was higher in workers not on sick leave during the follow-up.

**Table 8.2.** Matching FCE activities and WPA data and their relation to sick leave: a comparison per worker for eight activities

| Matching FCE and WPA | FCE < WPA | FCE ≥ WPA | FCE ? WPA |
|---|---|---|---|
| | Number of activities (n=8) | | |
| *Number of workers with sickness absence (n=6)* | | | |
| 1 | - | 3 | 5 |
| 2 | - | 6 | 2 |
| 3 | - | 8 | - |
| *Number of workers without sickness absence (n=12)* | | | |
| 1 | 2 | 4 | 2 |
| 1 | 1 | 5 | 2 |
| 1 | - | 6 | 2 |
| 2 | - | 7 | 1 |
| 7 | - | 8 | - |

Note. FCE = Functional Capacity Evaluation, WPA = Workplace Assessment; FCE < WPA = performance on FCE lower than performance at work; FCE ≥ WPA = performance on FCE equal to or higher than performance at work; FCE ? WPA = relation between FCE performance and performance at work unknown

# Discussion

This study investigated to what extent performance on FCE activities could be matched with observed work demands. Two different types of matching were used: direct and indirect matching. In indirect matching, an intermediate was used to correct for different situations. Of the eleven FCE activities analysed, seven activities could be directly matched with WPA data, (carrying, pushing, pulling, crouching, kneeling, static forward bending, and dynamic bending and rotating). For four workers, however, difficulties existed in matching three of the activities (pushing, pulling and crouching). One activity (lifting) could only be indirectly matched with WPA data by using the NIOSH lifting guideline as an intermediary to correct for different situations. One activity (walking) could not be matched with WPA data. Two activities (sitting and standing) were excluded from further analysis due to the limitations inherent in observing prolonged sitting and standing at the workplace. The main reasons for difficulties or non-matching were differences in task performance at the FCE and the workplace, that is, two-handed versus one-handed pushing, different lifting heights, differences in muscle groups used, and performance at the WPA exceeding the ceiling of the FCE test.

**Table 8.3.** Work characteristics and sick-leave data for workers with chronic low back pain

| Sick leave | | Yes | No |
|---|---|---|---|
| Work characteristic | Total group (n=18) | (n=6) | (n=12) |
| | n | n | n |
| Gender | | | |
| Male | 11 | 5 | 6 |
| Female | 7 | 1 | 6 |
| Worker | | | |
| White-collar | 12 | 4 | 8 |
| Blue-collar | 6 | 2 | 4 |
| Kind of occupation | | | |
| Day work | 14 | 4 | 10 |
| Shift work | 2 | 1 | 1 |
| Irregular work | 2 | 1 | 1 |
| Extent of occupation | | | |
| < 60% | 3 | 1 | 2 |
| ≥ 60% | 15 | 5 | 10 |
| Engagement | | | |
| Temporary | 1 | 1 | 0 |
| Permanent | 17 | 5 | 12 |
| Personal expectations[a] | | | |
| Full RTW new job | 2 | 1 | 1 |
| Full RTW previous job | 14 | 5 | 9 |
| | *Mean (SD)* | *Mean (SD)* | *Mean (SD)* |
| Age | 41.2 (8.4) | 38.4 (9.3) | 42.7 (8.0) |
| Years working in this occupation | 10.4 (6.7) | 8.7 (6.9) | 11.3 (6.7) |
| | *Median (IQR)* | *Median (IQR)* | *Median (IQR)* |
| VBBA physical exertion[b] | 24 (13-36) | 24 (7-37) | 24 (15-39) |
| VBBA physiological overload[b] | 27 (9-46) | 30 (8-52) | 26 (11-45) |
| FABQ-work[c] | 14 (5-19) | 6 (1-13) | 18 (9-21) |

Note. SD= Standard deviation; IQR = Interquartile range

[a] RTW = Return to work. Missing data of 2 workers; none of the workers filled in 'no RTW, partly RTW new job or partly RTW previous job

[b] VBBA = Questionnaire on perception and judgment of work. Results of 4 month follow-up

[c] FABQ-work= Fear avoidance beliefs questionnaire, work subscale. Missing data of 4 workers, of whom 1 was sick listed and 3 were working during follow-up year

Matching performance on FCE activities and WPA data could not be made five times (in two workers) due to data missing on the FCE. This provided no reason, however, for non-matching between FCE activities and work demands.

In this study, the IWS FCE was used as the standardized protocol, which could contrast with the specificity of the work demands observed at the workplace. It is known that the greater the level of standardization of a work-related assessment, the further it moves away from the actual work environment and requirements of a specific job.[36] A previous study developed a job-specific protocol (instead of a standardized protocol), which enabled a direct match between FCE activities and work demands.[37] Results of that study indicated that developing a job-specific protocol was possible by using observations at the workplace as a starting point. However, the IWS FCE was designed to be used both as a standardized protocol and as an adjusted protocol according to the demands of the workplace. Therefore, it is also important to know whether the standardized protocol of the IWS FCE is sufficiently specific in order for it to be able to be matched with specific work demands. From our study results, it can be concluded that seven of the reliable FCE activities are sufficiently specific to be able to be matched with observed work demands. However, because not all FCE activities are reliable and/or were able to be matched with work demands, not all observed work activities could be matched in the eighteen professions studied. This finding limits the content validity of the FCE with respect to work ability.

Not all tested FCE activities were relevant for all eighteen workers in their comparison with work demands. Other studies also questioned the relevance of some activities in the FCE with respect to their comparison with work demands.[38,39] In addition, pushing and pulling were tested using two hands, while in the observed occupations, the performance at the workplace was often single-handed. Also, in the FCE, the maximum holding time for forward bending is fifteen minutes (which is the ceiling of the test), while at the workplace no longer than seventy-six seconds of forward bending was observed. Previous research into the reliability of the FCE recommended eliminating ceiling effects in FCE activities.[13] From our study results, this recommendation seems only relevant for the crouching activity, because in this activity the ceiling of the FCE was reached during performance at work. However, in forward bending, for instance, the relevance of prolonged testing is not supported by the observed work demands in the eighteen occupations studied. It is, however, unknown to what extent the activities (with ceiling or criterion effects) in the FCE test represent performance over time (an eight-hour working day, five days a week, year in, year out). From these results, it is hypothesized that the item validity of some activities of the IWS FCE with respect to work demands is doubtful. It is recommended that the protocol be adjusted by determining item relevancy (for amplitude, frequency and duration) with respect to work demands.

No relation was found between FCE performance, work demands, and sick leave during follow-up. In almost all workers, FCE performance was higher than work demands. In only two workers was the FCE performance on pushing and pulling insufficient for the worker to perform his or her job. However, in those cases the workers did not resume work during follow-up. This might be explained by the substantial natural variation of the FCE tests of pushing and pulling. The natural variation of these tests were respectively 15.5 and 15.9 kg.[13] The difference between FCE performance and WPA data lies within this 15 kg range, and thus the work demands may not have really exceeded the performance on the FCE. Natural variation might also play a role in performance during the WPA. In this study, however, that variation was unknown. It is recommended in future studies that the natural variation of both FCE and WPA should be taken into account. At least three workers who were sick-listed during follow-up were not limited while performing any of the observed work activities at baseline. In addition, although workers with CLBP were limited in their performance of work-related activities, the workers' physical ability seemed sufficient to meet physical job requirements. A previous study (although linked to self-reported work demands) showed similar results, in that workers who met or exceeded physical job requirements were not working at the time of their follow-up interview due to their back problem.[19] From these results, we hypothesize that observed physical abilities are not important in predicting work ability in workers with CLBP. This hypothesis should, however, be confirmed in larger study samples and in a wider range of occupations.

The match between work ability and work demands was studied at the activity level. According to the expanded model of work load and work capacity[8], other factors encompassing functions, structures and environmental and personal factors also influence the relation between work demands, work capacity and sick leave (construct validity). Extra factors assessed in this study, whether white or blue-collar, kind and size of occupation, engagement, individual expectations of recovery, number of years working in the occupation, physical exertion, and physical overload, did not show any differences between workers with or without sick leave during follow-up. There was, though, a trend observed concerning fear avoidance beliefs about work, which were seen to be higher in workers not sick-listed during follow-up. This finding was, however, contrary to what was expected. Because a limited number of workers were studied, this finding might well only be a result of sample variation. In addition, it should be mentioned that both groups had low fear avoidance beliefs about work.

**Limitations of this study**

In matching performance on FCE activities and work demands, eighteen workers were studied. All eighteen workers had different occupations, for example, administrative worker, secretary, truck driver, service mechanic, or mailman. The eighteen different occupations made a wide range of inabilities available, but also increased the possibility of matching FCE activities and work demands. The relatively small number of workers, however, limited the generalizations possible from the study results. The influence of the match between work ability and work demands, as well as other factors in predicting sick leave during follow-up, should be investigated using larger study samples.

The match between work ability and work demands was based on the reliable items of the IWS FCE and was based on definitions and performance as used in this FCE. This means that in the comparison between work ability and work demands, the full physical domain was not covered, such as forward bending sitting. It should be pointed out that this study directly compared performance on FCE activities with work demands. Although it is possible for the FCE tests to be extrapolated to cover a whole working day, it is still not known how accurately the FCE test represents work demands over an entire day and to what extent the direct match between ability and demands made in this study is representative of a working day or week.

The reliability and validity of both the workplace assessment and the classification scheme used were unknown. An invalid exposure assessment could well explain the lack of quantitative data found on relationships between mechanical exposure and musculoskeletal disorders.[22] In addition, the lack of reliability and validity may also explain why in some workers the work demands exceeded the ability of the worker, while at the same time those workers did not report sick. Since this was an explorative study investigating the match between performance on FCE activities and work demands, these limitations are mainly important for the secondary aim of the study: the prediction of sick leave during the follow-up year.

It can be concluded that seven of the eleven FCE activities analysed could be directly matched with work demands. The standardized IWS FCE was not able to match with all observed work demands in the eighteen occupations studied. In clinical practice, this means that seven activities of the IWS FCE can be used to assess and evaluate whether a worker's performance is higher than his or her work demands in relation to specific work activities. When using the IWS FCE to predict work ability, it is recommended that the protocol be adjusted by determining item relevancy (in terms of amplitude, frequency and duration) with respect to work demands.

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# References


1. Andersson GBJ. Epidemiological features of chronic low back pain. *Lancet* 1999;354:581-5.
2. Waddell G. The physical basis of back pain. In: Waddell G ed. *The back pain revolution.* London: Churchill Livingstone, 1998;135-54.
3. IJzelenberg W, and Burdorf A. Patterns of care for low back pain in a working population. *Spine* 2004;29:1362-8.
4. Van den Hoogen HJ, Koes BW, van Eijk JT, Bouter LM, and Deville W. On the course of low back pain in general practice: a one year follow-up study. *Ann Rheum Dis* 1998;57:13-9.
5. Molano SM, Burdorf A, and Elders LAM. Factors associated with medical care-seeking due to low-back pain in scaffolders. *Am J Ind Med* 2001;40:275-81.
6. Van Dijk TJH, van Dormolen M, Kompie MAJ, and Meyman TF. Herwaardering model belasting-belastbaarheid [Revaluation of the model of work load and work capacity]. *Tijdschr Soc Gezondheidsz* 1990;68:3-10.
7. Van der Beek A. Assessment of workload in lorry drivers. *Thesis.* University of Amsterdam, 1994.
8. Heerkens Y, Engels J, Kuiper C, van der Gulden J, and Oostendorp R. The use of the ICF to describe work related factors influencing the health of employees. *Disabil Rehabil* 2004;26:1060-6.
9. Reneman MF, Fokkens AS, Dijkstra PU, Geertzen JHB, and Groothoff JW. Testing lifting capacity: validity of determining effort level by means of observation. *Spine* 2005;30:E40-E46.
10. King PM, Tuckwell N, and Barrett TE. A critical review of Functional Capacity Evaluations. *Phys Ther* 1998;78:852-66.
11. U.S. Department of Labor, Employment and Training Administration. *Dictionary of Occupational Titles*. Washington D.C.: 1986.
12. Abdel-Moty E, Fishbain DA, Khalil TM, Sadek S, Cutler R, Rosomoff RS, and Rosomoff HL. Functional capacity and residual functional capacity and their utility in measuring work capacity. *Clin J Pain* 1993;9:2003-13.
13. Brouwer S, Reneman MF, Dijkstra PU, Groothoff JW, Schellekens JMH, and Göeken LNH. Test-retest reliability of the Isernhagen Work Systems Functional Capacity Evaluation in patients with chronic low back pain. *J Occup Rehabil* 2003;13:207-18.
14. Fishbain DA, Cutler R, Rosomoff HL, Tarek K, Abdel-Moty E, and Steele-Rosomoff RRN. Validity of the dictionary of occupational titles residual functional capacity battery. *Clin J  Pain* 1999;15:102-10.
15. Gross DP, and Battié MC. The prognostic value of functional capacity evaluation in patients with chronic low back pain: part 2. Sustained recovery. *Spine* 2004;29:920-4.

16. Gross DP, and Battié MC. Predicting Timely Recovery and Recurrence Following Multidisciplinary Rehabilitation in Patients With Compensated Low Back Pain. *Spine* 2005;30:235-40.
17. Gross DP, Battié MC, and Cassidy JD. The prognostic value of functional capacity evaluations in patients with chronic low back pain: part 1. Timely return to work. *Spine* 2004;29:914-9.
18. Matheson LN, Isernhagen SJ, and Hart DL. Relationships among lifting ability, grip force, and return to work. *Phys Ther* 2002;82:249-56.
19. Gross DP, and Battié MC. Functional capacity evaluation performance does not predict sustained return to work in claimants with chronic back pain. *J Occup Rehabil* 2005;15:285-94.
20. Harbin G, and Olson J. Post-Offer, Pre-Placement Testing in Industry. *Am J Ind Med* 2005;47:296-307.
21. Wiktorin C, Karlqvist L, and Winkel J. Validity of self-reported exposures to work postures and manual materials handling. *Scan J Work Environ Health* 1993;19:208-14.
22. Winkel J, and Mathiassen SE. Assessment of physical work load in epidemiologic studies: concepts, issues and operational considerations. *Ergonomics* 1994;37:979-88.
23. Isernhagen Work Systems. *Functional Capacity procedure manual.* Duluth, MN: 1997.
24. Drury CG. Methods for direct observation of performance. In: Wilson JR and Corlett EN eds. *Evaluation of human work. A practical ergonomics methodology.* London: Taylor and Francis Ltd, 1995;2:45-68.
25. Kilbom A. Measurement and assessment of dynamic work. In: Wilson JR and Corlett EN eds. *Evaluation of human work. A practical ergonomics methodology.* London: Taylor and Francis Ltd, 1995;2:640-61.
26. Van Veldhoven M, Meijman TF, Broersen JPJ, and Fortuin RJ. Handleiding VBBA, vragenlijst beleving en beoordeling van de arbeid [Manual VBBA, questionnaire on perception and judgment of work]. Amsterdam: SKB Vragenlijst Services, 2002.
27. Van Veldhoven M and Meijman TF. Het meten van psychosociale arbeidsbelasting met een vragenlijst: de vragenlijst beleving en beoordeling van de arbeid (VBBA) [The measurement of psychosocial work load with a questionnaire: the questionnaire on perception and judgment of work]. Amsterdam: Nederlands Instituut voor Arbeidsomstandigheden [Dutch Institute for Working Conditions], 1994.
28. Van Veldhoven M and Broersen S. Measurement quality and validity of the "need for recovery scale". *Occup Environ Med* 2003;60:i3-i9.
29. Waddell G, Newton M, Henderson I, Somerville D, and Main CJ. A fear-avoidance beliefs questionnaire (FABQ) and the role of fear avoidance beliefs in chronic low back pain and disability. *Pain* 1993;52:157-68.

30. Vendrig A, Deutz P, and Vink I. Nederlandse vertaling en bewerking van de fear-avoidance beliefs questionnaire. [Dutch translation and adaptation of the fear-avoidance beliefs questionnaire.]. *Ned Tijdschr Psych* 1998;18:11-4.
31. Crombez G, Vlaeyen JWS, Heuts PHTG, and Lysens R. Pain-related fear is more disabling than pain itself: evidence on the role of pain-related fear in chronic back pain disability. *Pain* 1999;80:329-39.
32. Symonds TL, Burton AK, Tillotson KM, and Main CJ. Do attitudes and beliefs influence work loss due to low back trouble? *Occup Med* 1996;46:25-32.
33. Pfingsten M, Kroner-Herwig B, Leibing E, Kronshage U, and Hildebrandt J. Validation of the German version of the Fear-Avoidance Beliefs Questionnaire. *Eur J Pain* 2000;4:259-66.
34. Waters TR, Putz-Anderson V, and Garg A. *Applications manual for the revised NIOSH lifting equation.* Cincinnati, Ohio: DHHS (NIOSH) publication, 1994.
35. Astrand PO, and Rodahl K. *Textbook of work physiology: physiological bases of exercise.* Singapore: McGraw-Hill book company, 1986.
36. Innes E and Straker L. Workplace assessments and functional capacity evaluations: current practices of therapists in Australia. *Work* 2002;18:51-66.
37. Frings-Dresen MHW, and Sluiter J. Development of a Job-Specific FCE Protocol: the work demands of hospital nurses as an example. *J Occup Rehabil* 2003;13:233-48.
38. Kersnovske S, Gibson L, and Strong J. Item validity of the physical demands from the Dictionary of Occupational Titles for functional capacity evaluation of clients with chronic low back pain. *Work* 2005;24:157-69.
39. Lo EK, and Lam PC. Validity of the Dictionary of Occupational Titles as applied to construction site workers in Hong Kong. *Work* 2000;14:191-201.

# Appendix

| **Observed activities** | **Operational definition.*** |
|---|---|
| Walking | To move on foot, walking distance should be > 1 meter. |
| Crawling | To move on knees or hands and knees and to get into this posture. Including bending and rotating < 15 degrees. |
| Crouching | Maintaining position with knees and hips fully flexed, including the movement to get into this posture. |
| Kneeling | Maintaining kneeling posture (on one or both knees) including the movement to get into this posture. |
| Dynamic squatting | Smoothly bending knees and hips and standing up straight again. > 45 degrees flexion in knees and < 60 degrees trunk flexion. |
| Sitting | Maintaining a sitting position. Trunk flexion <30 degrees/ trunk rotation <15 degrees. |
| Forward bending static sitting 1 | In a seated position, bending the trunk and maintaining this bent position for 4 seconds. Trunk flexion between 30 and 60 degrees. |
| Forward bending static sitting 2 | In a seated position, bending the trunk and maintaining this bent position for 4 seconds. Trunk flexion > 60 degrees. |
| Rotation sitting | In a seated position, rotating the trunk and returning to the original position. The rotation lasts < 4 seconds. Rotations are more than 15 degrees. |
| Standing | Maintaining an upright position with standing on both feet. Knee flexion is <45 degrees in combination with trunk flexion < 30 degrees and trunk rotation <15 degrees. Movement < 1 meter. |
| Forward bending static standing 1 | In a standing position, forward bending the trunk and maintaining this position for 4 seconds. Trunk flexion between 30 and 60 degrees. |
| Forward bending static standing 2 | In a standing position, bending the trunk and maintaining this position for 4 seconds. Trunk flexion >60 degrees. |
| Dynamic bending 1 | In a standing position, bending the trunk and returning to the original position. Bending lasts less than <4 seconds. Trunk flexion between 30 and 60 degrees. |
| Dynamic bending 2 | In a standing position, bending the trunk and returning to the original position. Bending lasts < 4 seconds. Trunk flexion over 60 degrees. |
| Rotation standing | In a standing position, rotating the trunk and returning to the original position. Rotation lasts < 4 seconds. Rotations are more than 15 degrees. |
| Stair climbing | Going up or down fixed or movable stairs with horizontal, flat steps, where it is normally not necessary to use the hands. Specifying the number of steps. |
| Ladder climbing | Vertically moving oneself by means of ladders, scaffolding, crampons, dikes, roofs, in and out of trucks, etc, where the help of the upper extremities is necessary. |

| | |
|---|---|
| Low lifting | To manually lift, hold it for a short time (less than 10 seconds), and lower objects of more than 1 kg. The beginning and endpoint are less than or equal to 74 cm with respect to the absolute floor. |
| High lifting | To manually lift, hold it for a short time (less than 10 seconds) and lower objects of more than 1 kg. The beginning and endpoint are higher than 74 cm with respect to the absolute floor. |
| Left-handed long carrying | To lift left-handed, hold it for some time and lower objects of more than 1 kg. The object will be held for more than 10 seconds and/or will be carried for at least 1.20 meters. |
| Right-handed long carrying | To lift right-handed, hold it for some time and lower objects of more than 1 kg. The object will be held for more than 10 seconds and/or will be carried for at least 1.20 meters. |
| Two-handed long carrying | To lift with both hands, hold it for some time and lower objects of more than 1 kg. The object will be held for more than 10 seconds and/or will be carried for at least 1.20 meters. |
| Two-handed short carrying | To lift with both hands, hold it for some time and lower objects of more than 1 kg. The object will be held for more than 10 seconds and/or will be carried for 1 to 1.20 meters. |
| Static pushing 1 | Pushing objects using arm or leg power. Point of application between hip and shoulder height and with the body kept mainly still. |
| Static pushing 2 | Pushing objects using arm or leg power. Point of application not between hip and shoulder height and with the body kept mainly still. |
| Static pulling 1 | Pulling objects using arm or leg power. Point of application between hip and shoulder height and with the body kept mainly still. |
| Static pulling 2 | Pulling objects using arm or leg power. Point of application not between hip and shoulder height and with the body kept mainly still. |
| Dynamic pushing 1 | Pushing objects using full body weight. Point of application between hip and shoulder height, and with the body starting off and moving in the same direction as the object. |
| Dynamic pushing 2 | Pushing objects using full body weight. Point of application not between hip and shoulder height, and with the body starting off and moving in the same direction as the object. |
| Dynamic pulling 1 | Pulling objects using full body weight. Point of application between hip and shoulder height, and with the body starting off and moving in the same direction as the object. |
| Dynamic pulling 2 | Pulling objects using full body weight. Point of application not between hip and shoulder height, and with the body starting off and moving in the same direction as the object. |
| Driving in vehicles | For example truck driving, pallet vehicle, car, bus, etc. |
| Vibration | For example, drill, vibrating machine, etc. |
| Other | All other activities |

*Translated from Dutch into English for publication in this article; Trunk flexion is measured by drawing an imaginary line from hip joint to shoulder joint; Trunk rotations are measured by drawing an imaginary horizontal line through the shoulders.